Chapter 6
Maintenance Painting

6-1. Introduction

Maintenance painting of USACE structures provides an economical means for preventing corrosion and metal loss. This chapter explores the purpose of maintenance painting, provides details on conducting maintenance painting surveys, and details three approaches to maintenance planning.

a. Design problems. The design of a structure is generally centered on performance first, then longevity and efficiency. Only after those criteria are met is aesthetics considered. Because of this hierarchy, a successful structural design may present difficulties with the application of protective coatings. Back-to-back angles, sharp edges, and inaccessible areas restrict the coatings' ability to flow and provide coverage of the substrate. The use of dissimilar metals in design without regard to corrosion protection can result in extensive and costly repairs. Insufficient drain holes, which subject coatings designed for atmospheric exposure to an immersion service environment, subsequently cause failure. All design mistakes hinder the successful coating application and hence the performance, longevity, and ultimate efficiency of the structure and/or process.

b. Purpose of maintenance program. There are six reasons to properly develop, implement, and maintain a maintenance painting program: facility upkeep, corrosion protection, aesthetics, cost savings, energy conservation, and safety/identification. These factors all enter into the maintenance painting decision-making process.

(1) Facility upkeep. Facility upkeep is an all-encompassing concept. How smooth or well an operation functions can be a direct result of management's commitment to both the long- and short-term benefits of continual surveillance and remediation of corrosion. When the owner provides for continued maintenance, unscheduled shutdowns because of equipment and/or structural corrosion-related failures can be avoided. The rehabilitation of the facility then can be maintained through planned downtimes and/or scheduled preventative maintenance procedures.

(2) Corrosion protection. Corrosion protection, combined with loss of structural integrity, is generally the overriding and primary purpose of a maintenance painting program. When properly designed and maintained, major and costly procedures (complete removal and replacement) can be avoided. The location of corrosion may identify poor coating system selections and areas of poor design and construction. By designing a maintenance painting program strictly around corrosion, the results lend themselves to the identification and prevention of all other factors mentioned: operations, aesthetics, savings, conservation, and safety-related factors.

(3) Aesthetics. Aesthetic concerns vary considerably, depending on the specific industry. For example, manufacturing or fabricating facilities generally do not adopt or assign the same weight or importance to aesthetics as would those in the food industry. Accordingly, the appearance of a lock and dam is important because it is public property. It is visited by the public and represents the use of tax dollars. Tourist attraction areas may be more important aesthetically than some remote storage area. The degree of importance placed on aesthetics will have an effect on the frequency of painting, type of coating materials used, and color selection. If aesthetics is a motivating factor in a maintenance painting program, coating characteristics such as fading, chalking, checking, and rust stains will enter into the decision.

(4) Cost savings. Cost savings can be achieved if the maintenance program is designed so defects, such as corrosion, aesthetics, etc., are identified prior to the need for extensive surface preparation and recoating work. The life cycle cost of a coating is lessened considerably when regularly scheduled periodic repairs are performed.

(5) Energy conservation. Energy conservation also may be a consideration in specialized instances within a facility. Color selection is the key factor when energy conservation becomes a component or requirement within a program. An example of this would be the selection of a dark-colored coating on the exterior of a water storage tank. The increased heat generated on the interior may be sufficient to eliminate the formation of ice in the winter months and/or assist in some chemical reaction in a later process. If the structure is heated, the use of a light color could reduce the potential hazards with flammable and/or combustible material.

(6) Safety/identification. Safety/identification can be factors in a maintenance painting program if protection of employees and/or visitors is a predominant concern in a particular area or process. The Federal Aviation Administration (FAA) requires a checkerboard pattern on water storage tanks, radio towers, and other high structures near airports. Color-coded piping systems and nonskid deck coatings also are examples of color-coded material selection that enhances safety. First aid stations and fire extinguishers are commonly identified and located at a facility by color identification.

6-2. SSPC Paint Guide 5

The Steel Structures Painting Council (SSPC) Paint Application Guide No. 5, "Guide to Maintenance Painting Programs," provides procedures for planning and carrying out a maintenance painting program. This guide recommends that programs define the purpose of maintenance painting (corrosion protection, appearance, safety or identification, and energy conservation), consider the timing of the project (for example, short- or long-term painting program in time to schedule shutdowns), and recognize the economic issues and the need for environmental protection during the work.

6-3. Conducting Maintenance Painting Survey

a. Survey types. A brief summary of the types of surveys that can be undertaken to establish a maintenance painting program follows.

(1) Minimal walk-through survey. A minimal walk-through survey involves a subjective visual assessment of the overall condition of the coatings within a given area of the facility (lock, dam, public use area). The coatings within the areas are rated according to the painting needs of high, medium, or low priority, or some other qualitative rating scheme such as no coating work required, touchup only, or complete removal. When using a priority grading scheme, corrosion, process, contamination, safety, etc. all may be utilized as criteria. It may be helpful to conduct a quick walk-through of the facility to obtain an initial understanding of the range of coating conditions found throughout. This observation would provide a means of anticipating the amount of information to be gathered in the upcoming survey. If a wide range of conditions exist, more extensive testing may be required to determine the varying environments and causes of premature system failures. The initial walk-through provides an indication of the condition of the coatings and helps to establish a logical approach to organizing data collection.

(2) Midlevel survey. A midlevel survey will provide more information for planning maintenance painting than will the minimal survey. For a midlevel survey, drawings can be used to better divide the facility into well-defined areas. Within each area, painted items may be subdivided into categories such as structural steel, floors, tanks, piping, etc., rather than assessing the overall condition as a whole. This type of breakdown would provide a greater distinction between the items surveyed. An alternative would be to organize the items according to architectural, electrical, mechanical components, etc. An example would be to grade (examine) all structural items (walls, floors, ceilings) as architectural components under one grade, if all were in the same condition. The deterioration of the coating is assessed quantitatively in terms of visible corrosion, peeling, blistering, flaking, etc. The percentages of defects can be determined in accordance with SSPC VIS 2 or other custom-designed rating schemes. Specific rating scales for blistering are found in ASTM D714. Chapter 9 discusses inspection procedures in detail.

(3) Detailed survey. The detailed survey divides the plant into areas but further identifies individual components. For example, electrical equipment is not examined as a whole. Instead, individual motors are assessed, as are control boxes, conduit, etc. In addition, physical tests of the coating thickness, adhesion, and examinations of the substrate beneath the film are made for the presence of mill scale, corrosion, or deterioration. The advantage of this level of detail is that decisions can be made about whether the existing coating is of sufficient strength and integrity to be repainted, or if it is unable to support the application of additional coats.

b. Survey data. Although surveys generally can be classified as discussed here, various combinations of survey data can be developed. For example, a simple visual survey that qualitatively assesses the painting needs as high, medium, or low priority can be supplemented by a few physical tests of the coating integrity to determine if the existing system can be repainted without risk of disbonding. The various survey techniques and information that should be considered when collecting field data are described below.

(1) Area location. The specific location of the portion of the structure being surveyed is identified.

(2) Painted items. A listing of the painted items is compiled. Items may be inventoried as the smallest common element (e.g., pipes, stairs, railings, pumps, and motors) or as general categories (e.g., tanks, structural steel, floors, piping, and supports), depending on the level of complexity of the survey. When the need is to collect only general overall coating condition data, little to no individual inventorying of items is necessary.

(3) Service environment. The service environment for the coating system is identified. The environment includes not only the general operating conditions but any potential extreme or upset conditions such as temperature spikes, splash, and spillage. The service environment information is necessary when selecting maintenance coating systems. The most common service environments encountered are: interior, exterior (rural, residential, and industrial), immersion (liquid), temperature, and abrasion resistance. Detailed information on coating selection is found in Chapter 5.

(4) Existing coating type. If the percentage of corrosion and the adhesion of the remaining intact coating provide for overcoating, the existing coating must be identified to enable the selection of a compatible material for maintenance painting. If the coating type is not known through historical records, samples can be removed and analyzed in a laboratory to determine the generic type. Alternatively, ASTM D5043 provides a series of tests that can be conducted in the field to obtain a general indication about the generic type. The specific procedures are discussed in Chapter 3.

(5) Physical tests of coating integrity. The existing adhesion within the paint system is important if any overcoating is recommended. It also comes into play when examining the test patch results of candidate repair systems.

(6) Coating thickness. The film thickness of the entire system, as well as the individual layers, is important. This information and the corresponding adhesion may determine the type, level, and degree of surface preparation required if overcoating is recommended. This testing can be performed nondestructively and destructively as described in Chapter 9.

(7) Substrate condition. The underlying substrate must be examined for the presence of underfilm corrosion, rust scale, mill scale, or deterioration typical of the substrate itself (e.g., underfilm rust and rusting mill scale). The coating can be removed from adhesion test sites by cutting and scraping to examine the substrate, or through the use of chemical strippers. Deterioration of the underlying substrate may influence repainting decisions.

6-4. Analyzing Survey Data

a. The interpretation of the survey data requires the ability to change field test results into meaningful information. The painting needs of the entire area should be examined, not just individual components. The unnecessary application of additional layers or coats of paint can ultimately be a deterrent to the performance of a component because the additional paint now makes the system thick and heavy and can causing cracking, peeling, and subsequent detachment. It may be desirable to delay the rehabilitation (painting) of a badly corroded item until other items in the surrounding area also require work. As a result, there would be a delay in repainting certain isolated surfaces that need repair, which is the case in most maintenance painting programs. The objective is to identify and schedule those areas for repainting that require only minimal surface preparation. Cost-effective maintenance typically can be achieved if the amount of deterioration is less than 3 to 10 percent of the surface. Beyond this percentage, it may be more cost effective to allow the surface condition to continue to deteriorate and to schedule the items for total removal and replacement.

b. Common conditions analyzed to determine if an existing coating can be upgraded include: the extent of corrosion on the structure, the total thickness of the existing coating system (including the number of coating layers), the adhesion characteristics of the system, the condition of the underlying substrate, and the generic type of the existing system to ensure compatibility. Data needed to determine repairability of the coating include: visual assessment of the extent of corrosion and deterioration, flaking paint, physical tests of the coating thickness and adhesion, and an assessment of the substrate for mill scale and underfilm corrosion.

c. Not all coating systems are candidates for upgrading. For example, if the extent of deterioration is excessive, more surface preparation may be necessary than would be economically justifiable. The existing system may be of poor integrity and not strong enough to withstand the weight and stress imparted by the new system. Incompatibility between coating systems can result in softening and lifting of the existing system or poor adhesion to it. Any of these factors can result in cohesive and/or adhesive failure and increased costs because of needless or excessive system repair and replacement. Visual evaluations and physical testing are essential to prevent many of these, or similar, consequences.

6-5. Maintenance Painting Approaches

After the facility has been surveyed and the data analyzed to establish the high priority items for repainting, it is necessary to determine whether the coating should be touched up, touched up with a full overcoat, or completely removed and replaced. These maintenance options involve an assessment of both the overall percentage of coating deterioration and the physical attributes of the existing coating system. Total removal and replacement versus maintenance painting is typically considered when more than 3 to 10 percent of the coating has deteriorated. The wide range in percentages depends on the distribution of the corrosion across the surface. For example, a 3 percent coating failure distributed across an entire structure would be considered to be beyond the realm of touchup because, by the time each localized spot is properly prepared for repainting, a substantial amount of coating removal will have been necessary and there would be a significant number of overlap areas between the new material and the original system. Without extensive feathering of edges, each overlap can lead to a weakness in the total system, with lifting of edges and premature failure. When failure is more localized, as much as 10 percent or more of the surface may show deteriorated coatings, yet still be a candidate for maintenance painting because of the localized nature of the defects.

a. Integrity of existing coating. In addition to the distribution and percentage of corrosion, maintenance painting options are strongly influenced by the integrity of the existing coating. The point at which a coating is beyond consideration for rehabilitation because of its thickness or adhesion or the presence of underlying rust or mill scale varies according to coating type, the severity of the environment, the method of preparation to be used, and the coating system to be applied.

(1) Adhesion. ASTM D3359 adhesion ratings of 0A to 1A (removal of coating from most of the area within the X to beyond the X) or 0B to 1B (detachment within the lattice pattern from 35 to 65 percent of the area and greater) for many coatings would be considered to be associated with a high risk in recoating. However, areas of poor adhesion such as this have been successfully topcoated. Conversely, adhesion ratings of 3A and better (removal only up to 0.003 mm [1/8 in.] on either side of the scribes) or 3B and better (removal within less than 35 percent of the lattice pattern), which would typically be considered to be adequate adhesion for repainting, have been observed to spall. A definitive criterion for coating strength has not been established for the tensile adhesion tests, although a minimum of 1,378 kPa (200 psi) has been specified in the nuclear industry for coatings specified to be used within primary containment according to the American National Standards Institute (ANSI) N5.12-1974. When determining the ability to repaint a system based on adhesion, the tensile tests and knife tests may provide conflicting results. Industry professionals believe that adhesion testing, in general, is not a reliable predictor of coating performance. For example, coating systems that exhibit poor adhesion test values do not always fail, and systems that exhibit adherent test results sometimes fail prematurely. Because definitive rules for adhesion cannot be provided, decisions may have to be based on experience and subjective probing in conjunction with ASTM D3359, Method A knife test.

(2) Coating thickness. Coating thickness also plays a role in determining whether maintenance painting is a viable option. There are no established rules to determine when a coating is too thick to be repainted. For example, a 0.127-mm- (5-mil-) thick film with poor adhesion would not be a candidate for repainting, but a 0.635-mm- (25-mil-) thick coating with good adhesion might be a candidate for repainting. However, with aged alkyd systems, when the thickness measures 0.635 mm (25 mils) or more, the surface typically has already been repainted a substantial number of times, resulting in aged undercoats with poor cohesive and adhesive strength.

(3) Substrate condition assessment. The final assessment of the coating system that must be considered when determining repaintability is the presence of underlying mill scale or corrosion. The presence of mill scale or thin, tight corrosion is of less significance if the adhesion is good and the thickness is moderate. However, if the adhesion is suspect or poor, and/or the thickness is heavy, the presence of underfilm corrosion and mill scale becomes of greater importance. In many situations, it is not worthwhile to attempt the full overcoating of an old paint system of marginal integrity if mill scale and underfilm corrosion are present.

b. Hazardous material consideration. The presence of paints containing hazardous materials such as lead or chromate also can influence coating repair versus removal decisions. Under the Interim Final Rule on lead in construction, the presence of any lead in the existing coating, regardless of the amount, requires specific measures for employee protection. Small amounts of lead in vinyl paint and zinc-rich primer have been found. Although painting items with these systems is not normally considered to be a lead removal project, the OSHA requirements apply. The costs associated with the removal of lead paint can be extremely high because of the need for containment of the debris, the possible need for environmental monitoring of emissions, specialized worker protection requirements, and the controls needed for the handling and disposal of hazardous waste. Therefore, when assessing coating repair versus removal options, the cost associated with lead paint removal may make system touchup or touchup and overcoating to extend the life of the system a desirable alternative. Kline and Corbett (1992) discuss extending the life of an existing system, primarily a lead-based paint system. This chapter (paragraph 6-10) discusses these issues of maintenance painting in detail.

c. Maintenance painting options. Maintenance painting options are based on the amount of coating deterioration present and the physical integrity of the existing system. A discussion of the options follows.

(1) Spot repair (touchup) only.

(a) When only a few localized failures are occurring, or the integrity of the coating is such that it will not withstand the application of a full finish coat, localized spot repairs should be considered. However, spot repairs can be aesthetically unpleasing. If aesthetics permits, the spot repairs typically will be done economically to extend the life of the system and without risking wholesale detachment from the stresses imparted by application of full cosmetic coats. The selection of the surface preparation method is just as critical as coating selection. If the existing system is extremely brittle, the use of any abrasive blasting procedure may damage adjacent areas, thus creating a larger area of potential detachment and failure. The use of power tools offering a more controlled work area may be better suited to small, isolated repairs.

(b) Compatible systems must be selected to assure that there is no lifting at the overlap of the painted area. If the surrounding coating is painted at the same time, it must possess adequate strength and integrity to withstand lifting or disbonding from the application of the additional coats.

(c) The selection of upgraded coating systems should focus on materials with low shrinkage characteristics during curing and high solids content to minimize solvent penetration and softening of the underlying system. Because many upgrade projects involve large exterior structures subject to varying degrees of corrosive environments, the selection criteria also should include a substantial measure of resistance to atmospheric exposure and appearance.

(2) Spot repair (touchup) and full overcoating. Spot repair or full overcoating are the most traditional approaches to maintenance painting when the coating system can withstand the application of additional coats. Localized areas are spot repaired then a full overcoating is applied to the entire surface. A full coat is applied to correct localized pinpoint deficiencies that may not be visible during inspection or that may not be feasible for a one-for-one repair. Also, the longevity of the coating system typically is improved considerably through the application of a full overcoat.

(3) Complete removal and replacement. In a well-engineered maintenance painting program, the need for total removal and replacement of the coating system is minimized considerably. Coatings are repaired before the deterioration progresses to the point at which total removal and replacement is the only option. When a maintenance painting program is initiated, many areas of a structure may be in need of total coating removal and replacement, This is common when converting a facility to a properly engineered maintenance painting program.

d. Cathodic protection (CP). CP may be present and require an examination to ensure that it is performing as designed. This specialized field requires a properly trained professional. The periodic maintenance required with this form of corrosion protection, such as anode replacement, frequently is neglected. Candidate areas for installing CP may include areas that are difficult to prepare and paint or that, when repaired, cause a disruption in service.

6-6. Application of Test Patches of Coating Materials

a. Test patch application and analysis should be accomplished in accordance with ASTM D5064. Test patches should be applied to representative areas of the structure and be permitted to cycle through a winter season to apply additional environmental stress to the coating. If the cycle cannot be extended, a minimum of a few weeks curing time should be allowed prior to visual inspection for lifting, wrinkling, or other signs of incompatibility, and for an assessment of coating adhesion.

b. When preparing a coating for a test patch, the surface preparation must be carefully selected and should be included in the test programs just described. For old, aged, deteriorated coatings, compliance with SSPC-SP 7 may be too severe and may fracture and weaken the existing film; additional coats may cause detachment of this damaged coating. Scrubbing the surface to remove chalk, grease, oil, and dirt may be the only procedures needed.

c. If a coating system has been identified as "upgradable," test patches of the candidate system(s) should be applied prior to committing to upgrading on a large structure. Coating test patches frequently are applied in accordance with ASTM D5064. This standard covers the procedures for field testing of coating compatibility when maintenance of an in-place coating system is being contemplated.

d. If the coating is thick (0.635 to 1.016 mm [25 to 40 mil] or more) and the system's adhesion is poor to marginal, any decision to attempt recoating will necessitate the application of test patches. If test patches are not feasible, an additional method for determining the repairability of a system is to expose the samples to accelerated weathering using one of the weathering chambers described in Chapter 3. After weathering, the samples can be examined for lifting, loss of adhesion, and other physical characteristics. Obviously, total removal is preferable if it is economically feasible. However, when total removal is not feasible, and if test patches are successful, even areas containing otherwise poorly adherent coatings could be candidates for upgrading.

6-7. Identification of Existing Coating as Containing Lead

The existence of lead in a coating must be identified prior to considering maintenance alternatives. There are several methods for identifying whether or not a coating contains lead. Methods utilized for field determination include portable x-ray fluorescence (XRF) and chemical spot tests. Laboratory analysis of samples removed from the field is accomplished using atomic absorption spectroscopy (AAS) and inductive coupled plasma atomic emission spectrometry (ICP-AES).

a. X-Ray fluorescence.

(1) Portable XRF detectors are used directly on the painted surface to provide a nondestructive analysis of the amount of lead present. The lead in the coating is expressed as mass concentration per unit area in milligrams per square centimeter (mg/cm^2). The portable XRF detector utilizes a radioactive source (e.g., Co^{57}) and bombards the painted surface with x-rays that excite the lead atoms present. The intensity is measured by the detector and is related to the amount of lead in the coating. Although the testing of the paint film is considered to be nondestructive, the coating from representative substrate types must first be stripped to determine background values for each substrate. The readings obtained on the painted surfaces then are adjusted by subtracting the background values.

(2) Two types of portable XRFs are used: direct-reading and spectrum analyzers. The radioactive source in the detectors maintains its strength for approximately 1 year before replacement is required. The equipment costs range from $8,000 to $20,000 or more (1994 dollars), with the source replacement cost an additional $1,800 to $3,000 annually. Because of the radioactive source, the XRF operators must be trained by the equipment manufacturer and the owner licensed by the state in which the tests are performed. Therefore, it normally is not cost effective for an owner or contractor to purchase these machines for a few tests.

(3) Aside from the financial and licensing drawbacks, these XRF devices establish the lead content as a concentration over a given area; this is contrary to industrial paint evaluations for which the lead is expressed as a percent by weight. The influence of the steel substrate on the instrument reading also can affect the accuracy of the determination. Although the use of portable XRF detectors might provide an indication about whether or not lead is present on an industrial structure, no guidance is available on interpreting the results. As a result, it does not appear that portable XRF detection of lead in industrial paint will be used with any regularity in the near future.

b. Chemical spot tests. Careful use of spot tests may indicate that lead is present above a certain level, but the results are not quantitative. Also, the results can be misinterpreted: when lead is present but the color change is not recognized, or when lead-free coats mask the lead-containing coats from the test. However, spot tests for conducting initial field surveys and in conjunction with fewer (and more expensive) confirmatory samples submitted for laboratory analysis allow for more efficient and cost-effective sampling procedures. At a minimum, confirmatory samples for representative negative determinations are required. It is also wise to confirm a few positive samples as well. Chemical spot tests involve the use of sodium sulfide or rhodizonate, which react with lead-based paint and produce notable color changes. The procedures describing their use follow.

(1) Sodium sulfide. Spot testing using sodium sulfide is a qualitative method for determining the presence of lead. One method of conducting the test involves cutting a beveled scribe through the coating down to the substrate, exposing each of the layers within the coating system. A 6 to 8 percent aqueous solution of sodium sulfide is deposited across the scribe, and a reaction occurs between lead and the sulfide ion to form black lead sulfide. The change to a gray/black color typically occurs within seconds. If the existing coating is white, or a light color, and only one or two layers, this test may provide a viable means for determining whether or not lead is present. However, industrial paints typically are many layers, only a few of which may contain lead. An adequate area of each layer must be exposed to make the visual determination of color change. Additionally, the interpretation of a color change may be difficult with darker coatings, particularly when only thin layers are exposed for testing. The tester also must be able to distinguish between the darkening of a layer of the coating that may occur from the wetting solution compared to a darkening caused by exposure to sodium sulfide.

(2) Rhodizonate. Another spot test relies on the reaction between lead and the rhodizonate ion to precipitate a pink complex. The coating film is cut or sanded away to the substrate to expose a cross-section of the film, and a solution of rhodizonate is directly applied using a special applicator or applied to a filter paper that is placed against the surface. The reaction, which may occur instantly or require a few minutes, creates a rose-red coloration that indicates the presence of lead.

c. Laboratory analysis. Lead can be quantitatively identified and measured when properly sampled and analyzed in the laboratory. The laboratory analysis of lead content typically is accomplished using AAS or ICP-AES testing methods. The AAS tests are conducted in accordance with ASTM D3335. Methods 7420 and 7421 of the USEPA Manual SW-846, address lead detection by using a flame method and a graphite method, respectively. Method 7420 has a detection limit of 0.1 milligram per liter (mg/L) or parts per million (ppm). According to Method 7421, the detection limit using the graphite procedure is far greater at 1 microgram per liter (µg/L) or parts per billion (ppb). ICP-AES tests are conducted in accordance with Method 6010 (EPA SW-846).

d. Sampling procedures. Regardless of the laboratory method used for detecting lead, the samples selected for analysis must represent the range of coating thicknesses on the structure and the number of coats. The total thickness of the paint film must be removed cleanly to the substrate to ensure that the sample represents all of the coating within a well-defined area and that it is not diluted by a disproportionate amount of any coating layer. Controlling rust, mill scale, and other debris in the sample also is necessary to provide quality samples for laboratory analysis. The effects of undesirable materials in the sample will either invalidate the results because of the contaminates or increase the cost of the analysis because of the additional labor necessary to segregate the sample. Each sample should be submitted in a separate, sealed, and noncontaminated bag and identified with at least the project site, date, location from which the sample was taken, and name and signature of the sampler.

6-8. Impact of Costs of Lead Paint on Surface Preparation

In general, all activities associated with lead paint will be associated with high costs. Since the late 1980s and early 1990s, the industry has seen a significant increase in costs associated with concerns about lead and other hazardous materials. In response to these concerns, advances in the field of lead paint removal, primarily in the efficiency of containment/collection methods and the use of recyclable abrasives, have presented methods of cost control and enhanced worker and environmental protection. A major indirect cost of lead paint removal involving the concerns about the lead hazard includes environmental and worker protection, equipment, and labor.

a. Environmental and worker protection. A major indirect cost of lead paint removal involves the planning and engineering process necessary before commencing a project. The following discussion on the aspects of surface preparation costs affected by these lead hazard concerns includes environmental and worker protection, equipment, and labor. Chapter 11 specifically discusses these regulations. The factors affecting the regulation requirements include: worker protection and training, ventilation systems, air monitoring, and hazardous waste handling. Lead removal operations require enhanced levels of worker protection that add significantly to the costs of the project. Costs for compliance include new equipment (i.e., respirators), fit testing, training for each employee and supervisors, learning about and understanding regulations, additional paperwork to document compliance with OSHA and other standards, and increased insurance in some situations. There is a significant cost for the containment of the paint removal operations, for air and soil monitoring, and for disposal of the spent debris to ensure environmental protection. The largest cost item for full removal and repainting is containment and disposal; and it may be twice as expensive as when overcoating, but the projected coating life may be two to three times as long as overcoating. Cost increases because of environmental protection are difficult to accurately determine because compliance with nonstandardized requirements, which change regularly, depends to a large extent on the contractor's ingenuity and integrity.

b. Equipment. Equipment costs may be significantly higher when preparing surfaces containing lead paint. The factors affecting equipment costs include: initial investment or rental fees, removal effectiveness, quality of surface preparation, production rates, specific abrasives used, dust and debris generation, and containment required.

c. Labor. Labor costs invariably will be higher when maintaining a lead-based coating. Factors affecting labor costs include: production rate of the equipment used, extent of containment requirements, production losses caused by use of personal protection equipment, and training costs.

6-9. Maintenance Alternatives

Initial inspection of the existing coating system is necessary to determine the appropriate method of maintenance. No regulations require the removal of industrial lead paint; therefore, extending the life of an existing coating for 7 to 10 years through overcoating might provide a viable, cost-effective alternative for maintaining the structure. The cost of lead paint removal may or may not increase in the future and regulations may become more restrictive; however, prices may decrease because of the emergence of new technologies for lead paint removal and containment and as contractors gain more experience. Methods of maintaining a coating system containing lead include total removal and various techniques to upgrade the existing system. All maintenance alternatives for existing lead-containing coatings must comply with the worker protection requirements of the OSHA Construction Lead Standard (OSHA 6-9). Containment alternatives are discussed separately in this chapter.

a. Total coating removal and replacement. Total removal and replacement is the most costly alternative and may require elaborate controls over containment, worker protection, environmental protection, and debris handling and disposal. However, this alternative will provide the greatest system longevity, totally eliminate the hazardous paint, and eliminate the possibility of escalating removal costs in the future.

b. Coating system upgrading. Upgrading a coating system refers to the application of an additional barrier coat to increase the protective life of the existing coating system. Techniques to achieve cost savings by system upgrading include: spot touchup, partial removal, and zone painting. The overall advantages of upgrading the existing system include: considerable cost savings over total removal, utilization of future advances in lead removal technology, and cost-effective maintenance of the structure. Regardless of the actual costs for total removal versus rehabilitation, upgrading will be considerably less expensive. However, not all coatings or service environments are candidates for this approach, and the possibility of upgrading the system must be determined. The amount of spot repair required to assess the upgrade and to allow the contractors to bid on an equal basis also must be assessed. Methods of determining the upgrade of an existing system are discussed earlier in this chapter.

(1) Spot touchup. Spot touchup has several advantages. A minimal amount of lead paint is removed, and a less aggressive method of preparation can be used (e.g., hand- or power-tool cleaning). The impact on environmental emissions and worker exposures is greatly reduced, the containment needs are minimized, and the volume of waste is reduced.

(2) Partial removal. Partial removal may minimize the amount of lead paint to be removed if there is a sound intermediate coat over the lead primer. This alternative may provide a more cost-effective means of extending the life of the existing system with minimal surface preparation, if the work is scheduled before an extensive amount of rusting is visible, and if the existing system is of adequate strength and integrity to be recreated. If the intermediate coat is not sound, or many scattered spots of rusting are present and require preparation, the repair may dislodge enough lead to require additional environmental and worker protection and reduce the advantage of this alternative.

(3) Zone painting. Zone painting can increase the life of an entire system without specifying complete coating removal and replacement over the entire structure. The advantage is that the entire coating system is not arbitrarily removed and replaced because of severe deterioration in only a few places. The lead removal concerns are restricted to well-defined areas, and the remaining surfaces are overcoated at the same time.

6-10. Surface Preparation and Coating System Selection

a. Surface preparation alternatives. Surface preparation alternatives for a lead-containing paint coating are similar to typical preparation alternatives discussed in paragraph 6-5*c*. However, containment of the blast process is necessary because of potential overblast and hazardous debris concerns when preparing an existing lead-containing coating system. Abrasive spot blast cleaning will provide the best surface cleanliness and anchor profile necessary for many high performance coating systems, but it will generate the greatest amount of lead dust. However, if the existing topcoat is peeling but the underlying coatings basically are intact with minor pinpoint rusting, hand-tool cleaning (SSPC-SP 2) or power-tool cleaning (SSPC-SP 3) may be used to prepare the surfaces to minimize the generation of dust. The overall success of the repair depends highly on the quality of the surface preparation.

b. Coating system selection. The coating system selection process is similar to that of typical system selection methods. However, the added concern of further contamination from the remaining lead-containing coating must be addressed thoroughly prior to a final coating system selection. Compatibility between the existing coating and the candidate maintenance system is especially important, and test patches are strongly recommended.

6-11. Work Area Control Practices

After the ability to upgrade a system is determined and the alternative maintenance procedure is selected, work area practices must be established for control of lead exposure to the workers and to isolate hazards from surrounding operations and other personnel. Control practices should include precleaning of the work area, containment setup and isolation, establishment of a restricted area, and final cleanup. These practices are to be used when cutting, welding, or burning on surfaces coated with lead-based paint, or when hand-tool or power-tool cleaning, minimal blast cleaning, or chemical stripping processes are used for removal of lead-based paint on small area projects.

a. Precleaning. The precleaning procedure is used on all small area removal activities involving lead-containing paint coatings. Precleaning consists of vacuuming the immediate vicinity of the removal area within approximately 15 ft in all directions with a high efficiency particulate air filter (HEPA) vacuum to remove any existing debris or contamination.

b. Setup and isolation. Three methods of small work area setup and isolation are frequently used. The method selected depends on the dust-producing nature of the operations being performed.

(1) Minimal setup and isolation. A minimal setup should be used for operations that generate little or no airborne lead levels in the work area. Because there will be minimal generation of dust and debris, containment may be limited to the immediate work area. Minimal setups consist of protective coverings (typically 0.15-mm [6-mil] polyethylene sheeting) on the floor (or work platform) beneath the work area and extending approximately 3.05 m (10 ft) beyond in all directions. When work is performed on walls, the protective covering must be extended onto the wall and secured to the ceiling (or to at least 3.05 m [10 ft] above the work area). Objects that cannot be removed from the work area must be protected from contamination by the lead dust and debris. All drain openings in the work area must be sealed and plugged to prevent debris from escaping into storm drains and sewers. Access to the work area must be restricted to only those personnel involved in the project, and they must have completed the medical surveillance and lead training programs.

(2) Moderate setup and isolation. A moderate setup should be used for operations that generate a moderate amount of airborne lead in the work area. Because of the increased amount of dust generated, a more complicated containment system is necessary. A moderate setup consists of tarpaulins erected on all sides of the work area with joints overlapped to prevent emission of material into the environment. Impermeable tarpaulin materials typically are used. When the removal procedures involve chemical strippers, water- and chemical-resistant materials are used. Polyethylene sheeting is placed under and around the immediate work area. Objects that cannot be removed from the work area must be protected from contamination by the lead dust and debris. When the work area is defined by physical barriers, all openings must be sealed with polyethylene sheeting, and all drain openings in the work area must be sealed and plugged. Access to the work area must be restricted only to personnel involved in the project, and they must have completed the medical surveillance and lead training programs.

(3) Maximum setup and isolation. A maximum setup should be selected for operations that generate a large amount of airborne lead and that require the work area to be fully enclosed to establish a complete containment with ventilation. Maximum setups consist of substantial confinement systems, such as those defined as Classes 1, 2, and 3 in SSPC Guide 6I (Con), to contain the work area. Ventilation equipment, with dust collection on the exhaust air, must be used to reduce worker exposure. Access to the work area must be restricted only to personnel involved with the project, and they must have completed the required medical surveillance and lead training programs.

c. Restricted area. Two methods are used for establishing a restricted area around the removal activities: visual assessment and area sampling. The method to be used depends on the dust-producing nature of the operation being performed within the work area.

(1) Restricted area by visual assessment. Visual assessment is recommended when performing short-duration operations, or when the method generates little or no airborne lead. A zone 4.6 to 9.15 m (15 to 30 ft) in all directions of the work area must be isolated using tape, ropes, signs, and similar physical and visible barriers. Signs posted at the entrance and exit to the work area must read as follows: WARNING—LEAD WORK AREA - POISON - NO SMOKING OR EATING.

(2) Restricted area by area sampling. Area sampling should be used when the operation generates moderate to maximum amounts of airborne lead, or the project is of long duration. A zone is delineated using tape, ropes, signs, and similar physical and visible barriers. The air is monitored around the zone to establish the boundary beyond which the OSHA action level of 30 $\mu g/m^3$ will not be exceeded. Area samples are collected during representative operations throughout an entire work shift, and they are measured as an 8-hour time-weighted average (TWA). Specific air sampling procedures are discussed in Chapter 11. Air samples must be submitted to laboratories accredited by the American Industrial Hygiene Association (AIHA) and analyzed according to the National Institute for Occupational Safety and Health (NIOSH) Method 7082, or equivalent, for the appropriate metals analysis. If the results of the analysis determine that the exposure is below the action level, the restricted area should be established at that location. If the results are above the action level, the containment should be improved or the samplers should be moved further away from the work area and the testing repeated. Additionally, warning signs must be posted at the entrance and exit to the work area and should read as follows: WARNING—LEAD WORK AREA - POISON - NO SMOKING OR EATING.

d. Final cleanup. Cleanup applies to all removal activities of lead-containing paint and is imperative for the successful completion of the lead-removal process. Essentially, all visible accumulations of lead-containing materials and debris must be removed from the work area. Methods of contamination removal include HEPA vacuuming and placing debris in sealed containers. All surfaces in the work area, including reusable sheeting and tarpaulins, must be cleaned by HEPA vacuuming and wiping with at least 1 percent phosphate detergent or 5 percent trisodium phosphate solutions. All tools, equipment, and reusable tarpaulins must be free of lead contamination prior to removal from the isolated work area. On completion of cleanup and contamination removal, the work area must be reinspected for visible residue. If any accumulation of residue is observed, the area must be recleaned until no further residue remains.